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PRODUCTION OF GLASS MICROSPHERES USING THE PLASMA-SPRAYING METHOD

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Data on studying the production of glass microspheres by the plasma-spraying method are supplied. The effect of the operating parameters of the plasma gun on the granular composition of microspheres is investigated.

Plasma technology makes it possible to produce glass in the form of a conglomerate (by melting it in crucibles) or in the form of glass filaments and microspheres.

In recent years, glass microspheres have been increasingly used in the technology and engineering of various products. They are widespread abroad, in particular in the USA, Japan, Germany, and Great Britain. Certain application areas merit special attention. Microspheres are used as fillers in production of polymer composites, varnishes, and paints, in light-reflecting parts for cars and road signs, and in decorating articles, as well as in photoengineering, biotechnology, and electronics [1].

The size of the spheres is very significant. The spheres used as polymer fillers are 5 – 10 μm in diameter, the spheres used in light-reflecting car parts and ornamental articles have a diameter of 100 – 1000 μm or more, and the spheres used as abrasive material in treating metal surfaces have a diameter of 50 – 500 μm [2].

There now exist two main methods for producing microspheres [1]. The first method consists of making microspheres 5 – 500 μm in diameter by fusing previously crushed glass. The second method consists of the synthesis of microspheres 500 – 1500 μm in diameter by spray dispersion of a glass melt in a gas jet with subsequent chilling and trapping. The high temperature of plasma contributes to the significant intensification of the microsphere production technology. Microspheres are synthesized from high-melting and viscous glasses [3]. Spherical microparticles 60 – 80 and 300 – 650 μm in diameter were obtained from quartz glass in a high-frequency plasma discharge (USSR Inventor's Certif. No. 453911). Microspheres of aluminum-yttrium glasses of diameter 1100 – 2500 μm were synthesized in argon plasma by spraying glass batch previously molded as a rod [4].

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The present paper reports on the results of studying the production of microspheres by plasma spraying and the effect of the working parameters of a plasma gun on the granular composition of microspheres.

The initial materials were household glasses produced at the Krasnyi Mai Glass Factory JSC (Table 1). Microspheres were produced employing the GN-5r burner of a UPU-8M plasma gun. Argon served as the plasma-forming gas. The plasma-gun parameters were as follows: working voltage 30 V, strength of current 350 – 450 A. The argon consumption varied in the limits 0.00093 – 0.00163 g/sec.

The process of microsphere production included the following stages (Fig. 1). Glass rods 1.0 – 2.5 μm in diameter are automatically inserted inside the plasma burner *1*, where, under the effect of high temperature, the front end of the rod fuses, the melt is dispersed, and microspheres are formed in the plasma-forming gas flow. The microspheres partially cool while moving along the refractory cone *2* and finally

TABLE 1

Glass*	Mass content,** %						
	SiO_2	Al_2O_3	CaO	Na_2O	K_2O	SO_3	Fe_2O_3
Chromium-tinted green household	72.7	–	6.8	15.0	2.0	0.5	0.05
Cobalt-tinted blue household	68.6	6.3	9.3	14.8	1.0	–	0.05
Milky	66.8	6.3	6.3	14.8	1.0	–	–
Selenium ruby household	66.5	1.0	–	13.0	6.0	0.4	0.05
Clear household	71.0	1.0	6.0	13.0	4.0	0.5	0.10

* Cr_2O_3 content in household green glass was 1.0%, CoO content in household blue glass 0.002%, Cd and Se in household selenium ruby glass was 0.5% each.

** In addition, household green glass contained 2.0% MgO, milky glass had 5.0% F, and selenium ruby household glass had 8.0% ZnO and 3.5% B_2O_3.

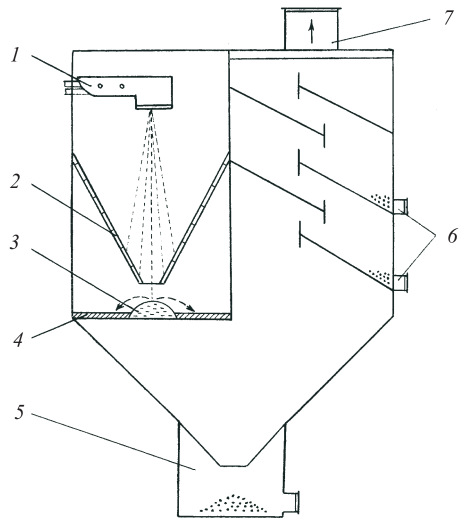

Fig. 1. Diagram of microsphere production.

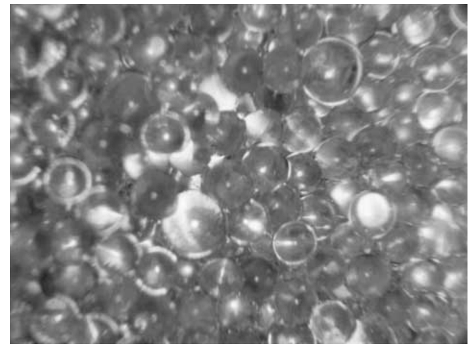

Fig. 2. Microspheres of size 320 – 630 μm (× 12).

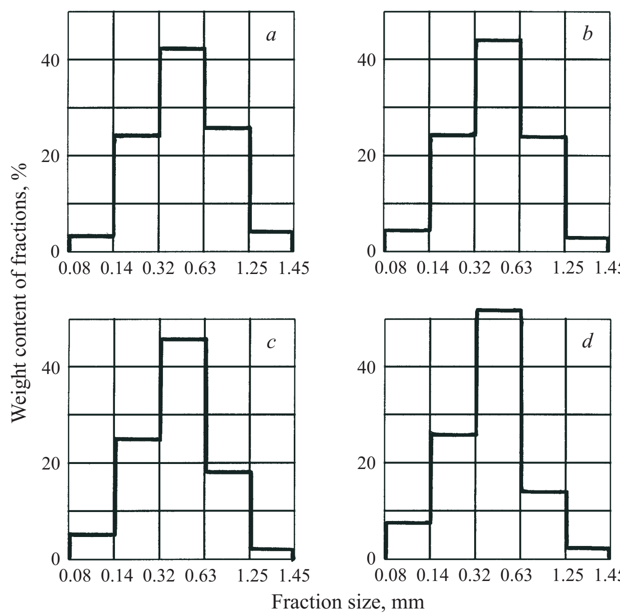

Fig. 3. Granular compositions of particles arising in plasma spraying of glass rods ands tubes: flow rate of plasma-forming gas 0.00093 (*a*), 0.00116 (*b*), 0.00140 (*c*), and 0.00163 g/sec (*d*).

cool on entering into contact with the water-chilled metal hemisphere *3*. After an impact with the hemisphere, the microspheres arrive at the vibration sieve *4*, where non-standard beads and particles are removed. The large-sized microsphere fractions of diameter more than 630 μm are accumulated in a container *5*, whereas small-sized spheres are discharged via the pipeline *6*. The plasma-forming gas is removed via forced ventilation *7*.

The experiments show that the flow rate of the plasma-forming gas has an effect on the granular composition of the microspheres (Fig. 2). Microspheres of size 320 – 630 μm comprise 42 – 52% of the total weight (Fig. 3). As the rate of the plasma-forming gas grows from 0.00093 to 0.00163 g/sec, the amount of fractions of diameter 80 – 630 μm increases, and that of diameter 630 – 1250 μm decreases. The largest fractions 1250 – 1450 μm in diameter on the average amount to 2.5 – 5.0% of the total weight.

The microscopic studies identify gas inclusions of diameter 20 – 50 μm in the microspheres. It is known [5] that the partial pressure of soda-lime glass vapors in the temperature interval 2000 – 3000 K, which can be reached in the surface layer in the course of plasma treatment, keeps decreasing in the following sequence: $K_2O - Fe_2O_3 - SiO_2 - CaO$. Thus, alkaline oxide compounds are the first to volatilize and decompose, and silicon and calcium oxides are the last to do so.

In our case, the microspheres of household glasses were depleted of R_2O oxides on the average by 0.7 ± 0.2% and enriched in calcium and silicon oxides, respectively, by 0.6 ± 0.2 and 0.9 ± 0.2%. This led to the modification of the refractive index by 0.005 – 0.008 and increased the chemical resistance in the microspheres. The latter is one of the advantages of the plasma technology compared to the known traditional methods for producing glass microspheres.

Thus, the production of glass microspheres using plasma spraying is a promising direction, which makes it possible to ensure a high quality of the final product and environmental safety.

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